
Introduction Of Domestic Reduced Vertical Separation Minima (RVSM)

Final Report

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Table of Contents

1	Introduction	1
2	Technical Approach and Study Methodology.....	2
3	Input Data and Selection of Baseline Day	3
3.1	Airline Load Factor Data	3
3.2	ETMS Data	3
3.3	Wind Data	3
3.4	RVSM Capability	6
3.4.1	Master Minimum Equipment List (MMEL) for Reduced Vertical Separation Minimum (RVSM) Operations.[4].....	6
3.4.2	RVSM Capable Aircraft.....	7
4	Baseline Scenario	8
4.1	Traffic Analysis	8
5	RVSM Scenarios	10
5.1	Data Preprocessing and OPGEN run.....	10
5.2	Scenario Descriptions	10
6	Results.....	12
6.1	Operational Impacts.....	12
6.2	Fuel Savings	18
7	Conclusions and Recommendations.....	19
8	References.....	20
	Appendix A Load Factor Data	A-1
	Appendix B Wind Data	B-1
	Appendix C Aircraft Types.....	C-1
	Appendix D Aircraft Data Structure.....	D-1
	Appendix E Distribution of Altitude Changes.....	E-1



List of Tables

<i>Table 3.2-1</i>	<i>Daily Number of Flights</i>	<i>3</i>
<i>Table 4.1-1</i>	<i>Altitude Distribution of Traffic.....</i>	<i>8</i>
<i>Table 6.1-1</i>	<i>Aircraft Altitude Changes</i>	<i>17</i>
<i>Table 6.1-2</i>	<i>Traffic Counts Within Impacted Altitude Bands.....</i>	<i>18</i>
<i>Table B-1</i>	<i>Pressure Levels and Corresponding Altitudes</i>	<i>B-2</i>



List of Figures

Figure 3.3-1	300 Mb Wind Speeds (0:00 Zulu).....	4
Figure 3.3-2	300 Mb Wind Speeds (12:00 Zulu).....	5
Figure 3.3-3	NEXRAD National Mosaic Reflectivity Image (0:00 Zulu)	5
Figure 3.3-4	NEXRAD National Mosaic Reflectivity Image (12:00 Zulu).....	6
Figure 4.1-1	Aircraft Cruise Altitudes - Baseline	8
Figure 5.1-1	Generating the RVSM Demand Scenario	10
Figure 5.1-2	Baseline Transition to RVSM (FL350 – 410).....	Error! Bookmark not defined.
Figure 6.1-1	Cruise Altitude Distribution of Candidate Flights - Baseline.....	12
Figure 6.1-2	Cruise Altitude Distribution of Candidate Flights – RVSM Implementation Option #1 ((FL350 – FL410))	13
Figure 6.1-3	Flight Stage Length Distribution of Candidate Flights	14
Figure 6.1-4	Flight Level Changes Due to RVMS Implementation – RVSM Implementation Option #1 ((FL350 – FL410))	15
Figure 6.1-5	Hourly Change in Traffic Count – RVSM Implementation Option #1 (FL350 – FL410)	16
Figure B-1	Infrared Satellite Image & 300 Mb Jet Stream Analysis (AVN model).....	B-1
Figure B-2	300 Mb Wind Speeds	B-3
Figure B-3	Jet Stream Vertical Profile.....	B-4



1 Introduction

Vertical separation standards are currently being reduced in select oceanic airspace yielding reduced vertical separation minima (RVSM). The airspace user community has posed significant interest in introducing RVSM within domestic airspace. However, the impact to users that would not likely be equipped with the avionics necessary for RVSM must be minimized. Several implementation strategies have been put forward to approach this task, including introducing RVSM within certain altitude bands. To date two alternate altitude bands have been discussed. The first of these bands is from FL350 to FL410 and the second from FL370 to FL410. However, before the concept of domestic RVSM and these implementation alternatives can be seriously considered, the impact that they present to the user community must be evaluated. The purpose of this study is to perform a preliminary feasibility assessment of these implementation alternatives.

The remainder of this report presents:

- the study approach
- a description of input data sources
- a description of the baseline day
- a description of the RVSM scenario
- analysis results
- conclusions



2 Technical Approach and Study Methodology

The technical approach for performing this study consisted of the following steps:

- 1) The baseline scenario consisted of as-flown traffic scenarios derived from Enhanced Traffic Management System (ETMS) data using the National Airspace Resource Investment Model (NARIM). The scenario was based on as-flown data and therefore reflected what actually happened on the scenario day (i.e., path of flight, controller intervention actions, and traffic management initiatives in place).
- 2) RVSM scenarios were generated for the two scenario days using OPGENTM. In generating these flight profiles, the vertical trajectory of the flight was optimized for winds aloft (i.e., the horizontal track remained as actually flown).
- 3) Next, the baseline scenarios (i.e., as-flown operations) were compared with the RVSM scenarios (i.e., wind-optimized operations) to determine the operational impacts. Impacts on the both users and the air traffic service provider were assessed.



3 Input Data and Selection of Baseline Day

3.1 Airline Load Factor Data

Generating RVSM scenarios (i.e., wind-optimized flight profiles) required accurate aircraft weight data, necessitating accurate airline load factor data [1], [2]. The most recent available load factors, derived from DOT Form-41 data, were purchased from Data Base Products, Inc. The load factors were for the month of March 1999, for the top 500 non-stop markets and were broken down by airline. The data was provided in Excel™ format (sample shown in Appendix A).

3.2 ETMS Data

To generate the baseline scenarios, ETMS data was obtained for a portion of the month of March 1999. A cursory evaluation of the suitability of each day was performed based upon the size of the associated data files. The ETMS data was parsed for the following March 1999 days: 14th, 16th, 17th, 18th, 19th, 20th, 21st, 22nd, and 24th. Table 3.2-1 provides the number of as-flown CONUS flight tracks extracted from ETMS data for each of these days.

Table 3.2-1 Daily Number of Flights

Day	Day of the Week	Number of Flights
3/14	Sunday	26,764
3/16	Tuesday	40,754
3/17	Wednesday	40,805
3/18	Thursday	40,988
3/19	Friday	40,730
3/20	Saturday	34,849
3/21	Sunday	25,571
3/22	Monday	36,417
3/24	Wednesday	41,753

3.3 Wind Data

One of the first tasks required was to determine how many scenarios days were necessary to account for differences in the position of the jet stream relative to the candidate altitude bands (i.e., FL350 – FL410). The concern was that if the jet stream on the scenario day fell beneath the candidate altitude bands the study results would be much different than if it was within the candidate altitude bands. Appendix B provides a detailed description of the analysis performed to determine the location and vertical depth of the jet stream and a description of the sources investigated for wind data.



Gridded wind data was analyzed for the nine candidate scenario days to determine the altitude of and the variation within the jet stream. The maximum speed ranged from 60 to 80 knots for the nine days. The vertical profiles of the jet stream indicated that there were no days where the jet stream was distinctly outside of or varied considerably within the proposed RVSM bands (i.e., FL 350-410 and FL 370-410). Therefore, a single day was determined to be sufficient for this analysis.

Based on the number of flights, wind data and ground observations, March 24, 1999 was selected as the scenario day. Figures 3.3-1 and 3.3-2 illustrate the position of the jet stream (i.e., 300 Mb chart) at 0:00 and 12:00 Zulu on Wednesday, March 24, 1999. Figures 3.3-3 and 3.3-4 are NEXRAD mosaics at 0:00 and 12:00 Zulu on March 24, 1999, and indicate good surface visibility (i.e., low probability of weather-related TFM initiatives).

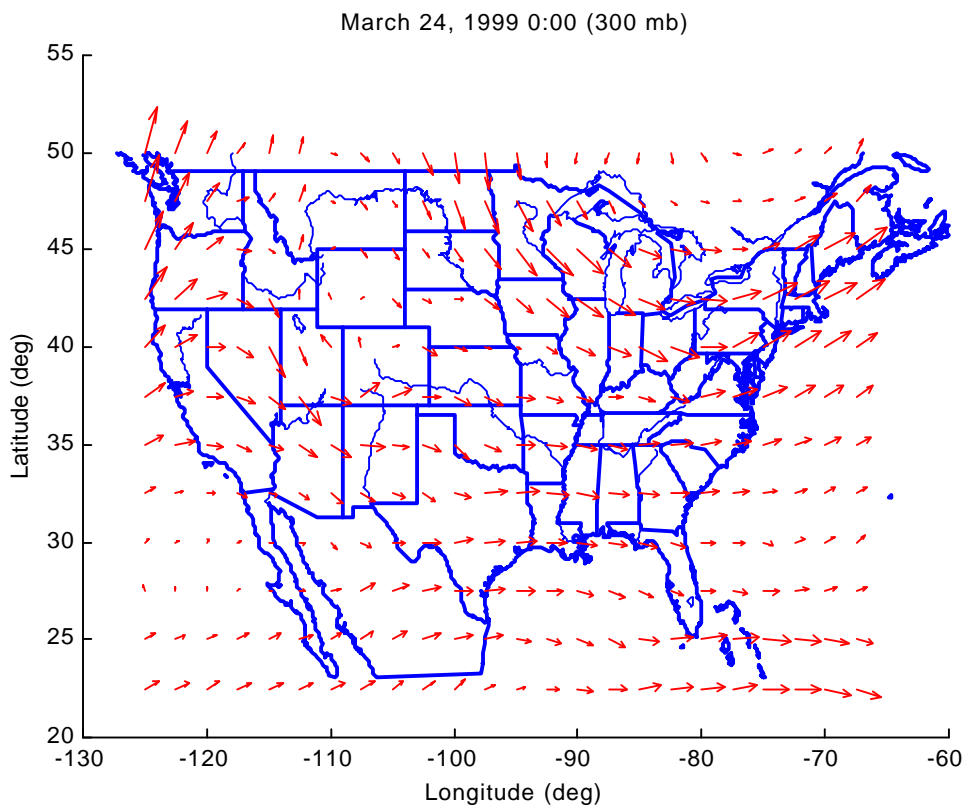


Figure 3.3-1 300 Mb Wind Speeds (0:00 Zulu)



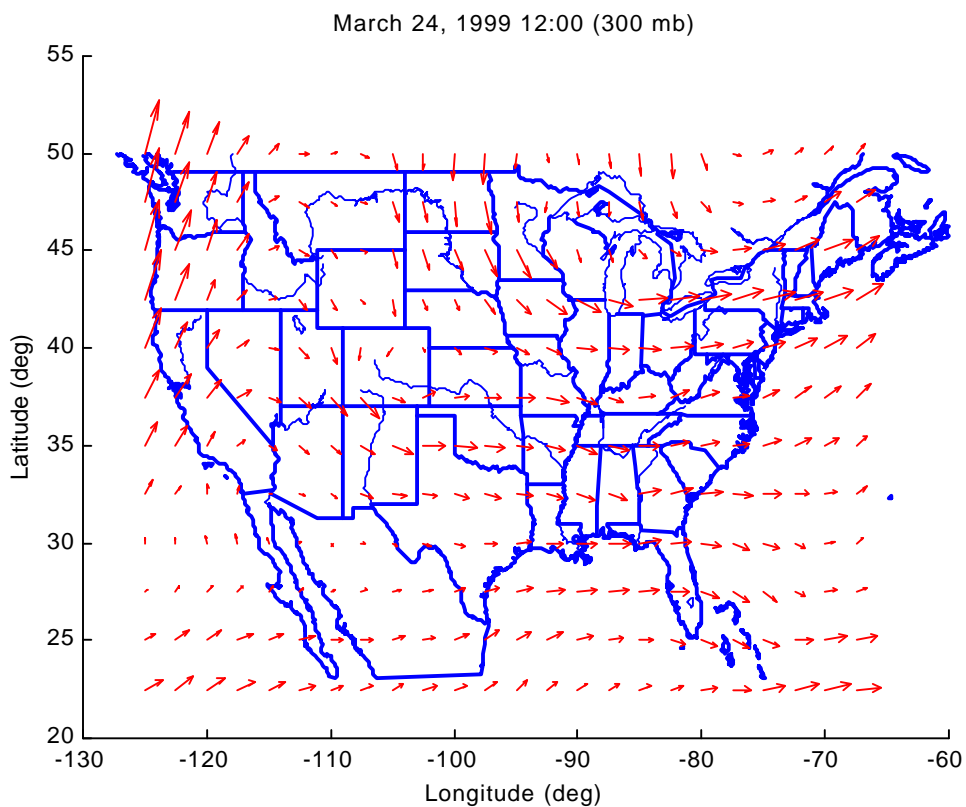


Figure 3.3-2 300 Mb Wind Speeds (12:00 Zulu)

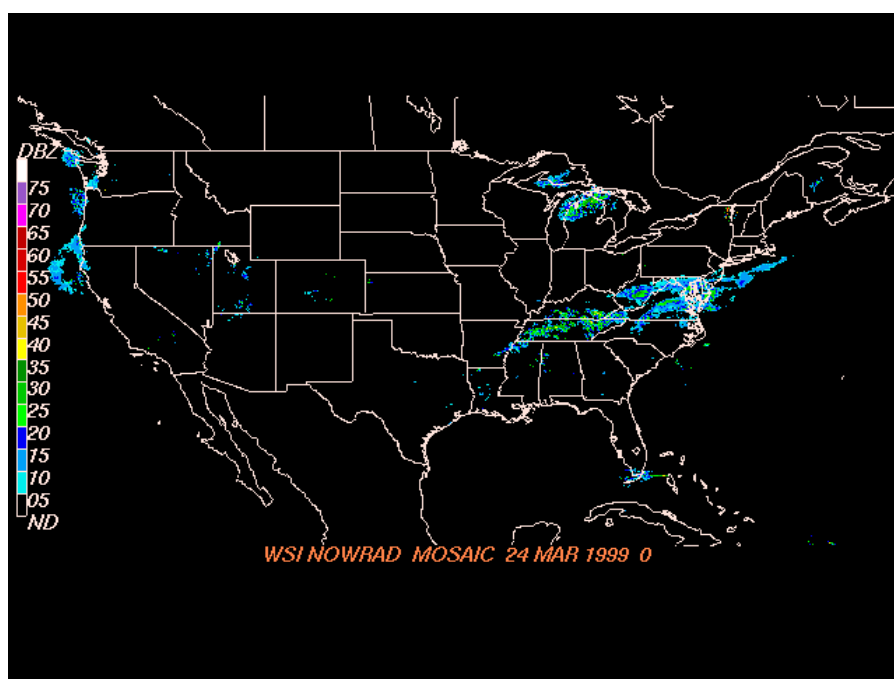


Figure 3.3-3 NEXRAD National Mosaic Reflectivity Image (0:00 Zulu)



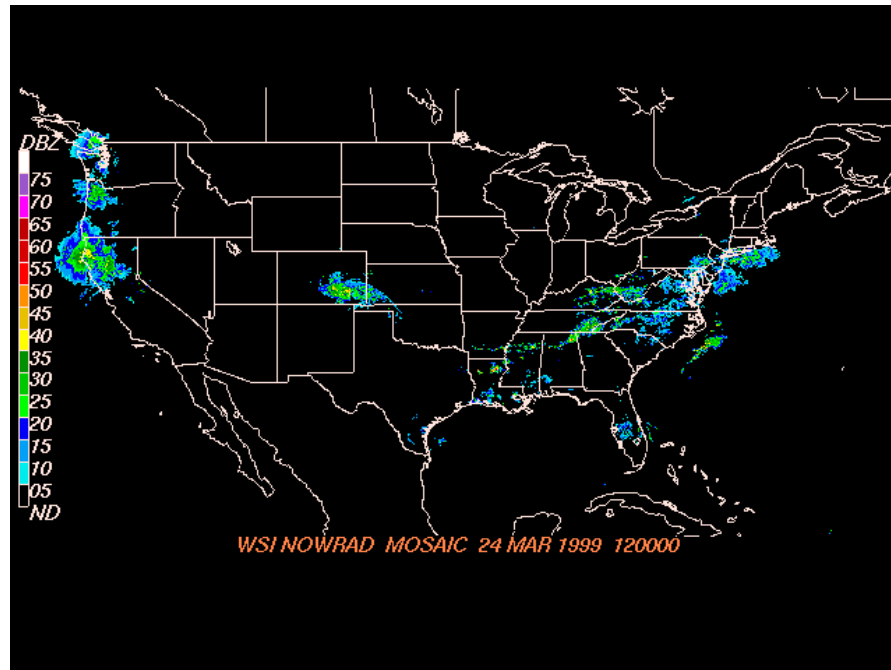


Figure 3.3-4 NEXRAD National Mosaic Reflectivity Image (12:00 Zulu)

3.4 RVSM Capability

To determine which aircraft would be capable of domestic RVSM operations, we drew upon our experience with oceanic RVSM implementation. Oceanic RVSM operations require a Minimum Equipment List (MEL) as defined in Section 3.4.1. Section 3.4.2 describes the criteria that we applied to determine RVSM capability for the purposes of this study.

3.4.1 Master Minimum Equipment List (MMEL) for Reduced Vertical Separation Minimum (RVSM) Operations.[4]

The following systems are required to be installed on aircraft to be approved to conduct RVSM operations:

- Two (2) independent altitude measurement systems (as defined in FAA Interim Guidance 91-RVSM, paragraph 8a).
- One (1) secondary surveillance radar (SSR) reporting transponder.
- One (1) altitude alerting system.

In addition, there is an operational requirement for certain systems to be operating at entry into airspace where RVSM is applied. They are:

- Two (2) independent altitude measurement systems.
- One (1) altitude alert system.
- One (1) automatic altitude control system.



These generic equipment requirements reflect the current operational environment for oceanic RVSM. However, there may be a need to assess specific aircraft and systems independently. Instances where this need may arise include aircraft where unique design features and/or service history identify the need to address other unspecified equipment requirements (e.g., operational limitations of the B-747 classic that may mandate the use of autothrottles to preclude unacceptable Mach excursions which can induce altimetry system errors).

3.4.2 RVSM Capable Aircraft

Appendix C contains a list of aircraft types contained in the March 24, 1999 ETMS data and descriptions of each from References [1] and [2]. For the purposes of this study, an aircraft's capability to be RVSM equipped was based on the following criteria:

- Aircraft that have been already approved for RVSM operations in the Northern Atlantic and Pacific regions [3] and all military aircraft are considered to be RVSM capable for the NAS and indicated as such by a check-mark in the last column of Appendix C.
- Turbo-jet engine aircraft not contained in [3] are considered to be RVSM capable if the MMEL equipage cost (i.e., \$200,000-\$600,000+) is significantly lower (i.e., about 10%) than replacement cost. A significant proportion of these aircraft already operates within proposed RVSM flight bands.

Aircraft that satisfy these criteria but are not yet RVSM approved were considered to be RVSM capable for the purposes of this study and are indicated by the letter "Y" in the last column of Appendix C. Aircraft that do not satisfy these criteria were not considered to be RVSM capable and are indicated as such in Appendix C by a letter "N".



4 Baseline Scenario

4.1 Traffic Analysis

Table 4.1-1 shows the vertical distribution of air traffic for March 24, 1999.

Table 4.1-1 Altitude Distribution of Traffic

Flight Levels	Number of Aircraft	Percentage of Aircraft
FL below 290	22,709	54.39
FL 290-410	18,769	44.95
FL 350-410	9,430	22.58
FL 370-410	4,727	11.32
FL above 410	275	0.66
Total	41,753	100%

Figure 4.1-1 is a histogram of the number of flights at each allowable flight level within the altitude bands in which RVSM is being implemented in the Pacific and North Atlantic regions (i.e., FL290 – 410).

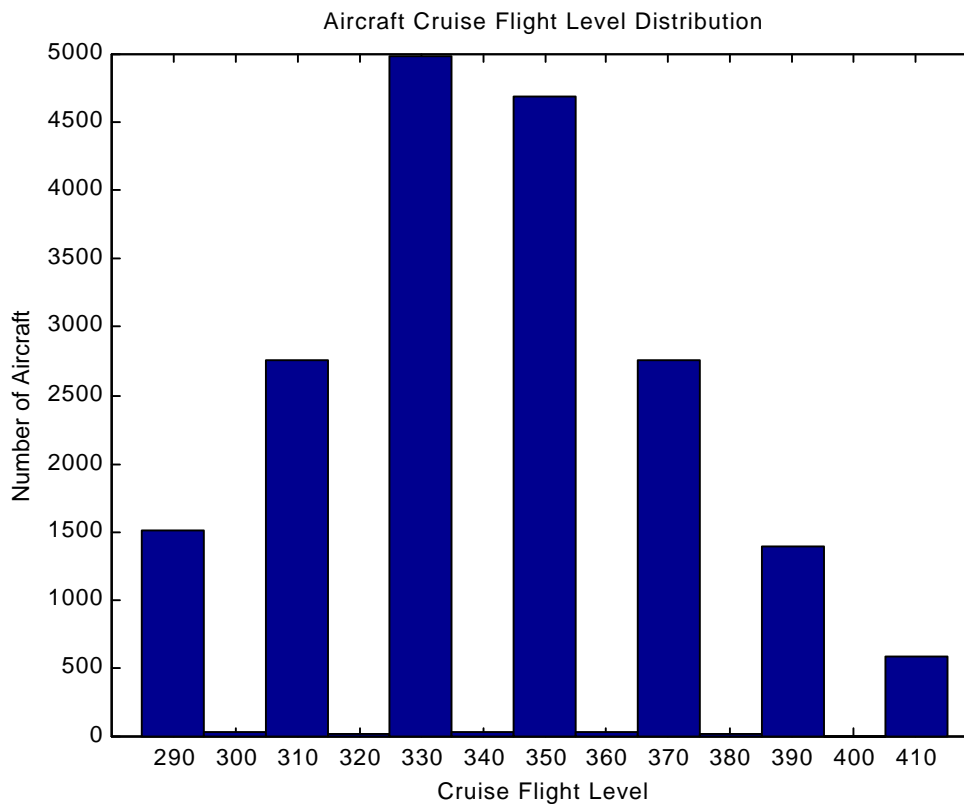


Figure 4.1-1 Aircraft Cruise Altitudes - Baseline



Appendix D provides a sample of the aircraft data structure generated from ETMS data for use in this study.

Based solely on our RVSM capability criteria, there were approximately 12,360 additional flights that could operate within the FL 350-410 flight band. However, not all of these were considered. RVSM capable flights also had to satisfy criteria regarding stage length. Flights had to also be between 500 nmi and 2300 nmi in length (imposed to exclude European and Asian international flights). Of the flights that satisfied these criteria only 20 (6 for FL 370-410) are not capable of operating under RVSM conditions based on the RVSM capability requirements discussed in Section 3.4. Flights in which the aircraft type was indeterminable from ETMS data were randomly assigned an aircraft type in order to preserve the distribution of flights by type in the baseline data.



5 RVSM Scenarios

5.1 Data Preprocessing and OPGEN run

The output of the TZ parser was modified for input to OPGEN in the following manner:

1. The output of the TZ parser contains some flight tracks that actually represent two distinct flights. This occurs infrequently when an arrival message is not received for the original flight and a departure message is not received for a subsequent flight departing within a very short time period of the first flight's arrival. Such flight tracks were processed further to ensure that they are properly split.
2. Track records were interpolated to provide more equal spacing (i.e., required for optimization) to remove the significant time variation of TZ data updates (from tens of seconds to tens of minutes).
3. Flight tracks shorter than 20 minutes were not considered since they did not provide sufficient data for optimization. However, since flights had to be greater than 500 nmi to be included in the analysis the impact of disregarding these flights should be minimal.

Once these additional processing steps were performed, the scenario file was prepared for input to OPGEN. The process of setting up OPGEN run is described on the following simplified diagram.

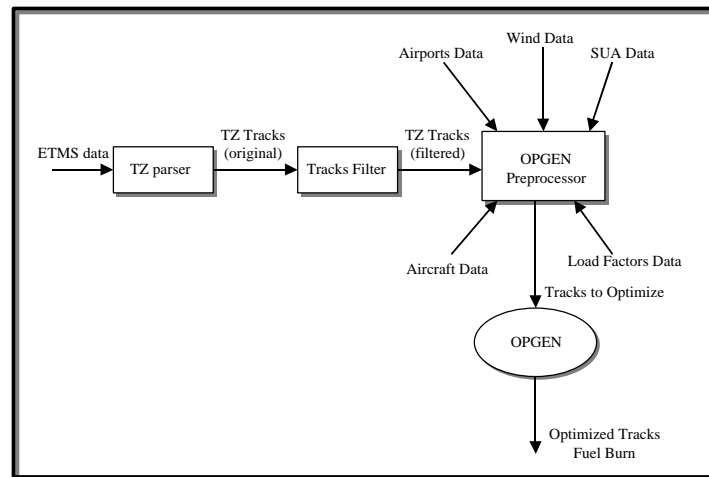


Figure 5.1-1 Generating the RVSM Demand Scenario

5.2 Scenario Descriptions

OPGEN runs were performed for both domestic RVSM implementation options. For the first implementation option (i.e., FL350 – FL410) FL350, FL360, FL370, FL380, FL390, FL400, and FL410 were permissible cruise altitudes. For the second implementation option (i.e., FL370 – FL 410) FL370, FL380, FL390, FL400 and FL410 were permissible cruise altitudes.



Altitude separation below FL350 was preserved according to the current concept of operations (i.e. 1000 ft for flights below FL 290 and 2000 ft for flights above FL 290). The horizontal tracks of aircraft were not changed, only altitude optimization was performed. Special Use Airspace (SUA) activation times were set to zero in OPGEN since longitudinal tracks remained as-flown. Load factors were used for aircraft type and city-pairs available. The national average load factor (i.e., 0.6726) was used for all other cases. Only flights with a stage length of 500 nmi or greater were optimized. The altitude cutoff for optimized tracks was 24,000 ft (i.e., the portion of the flight track below 24,000 ft. was not optimized). Alternatively in many cases flights (i.e., depending on direction of flight) could remain at the same cruise altitude.



6 Results

6.1 Operational Impacts

Based on the criteria used for this study (i.e., RVSM capability and stage length) there were 4,912 flights considered for the two different domestic RVSM implementation options. Appendix E contains a table that provides the complete results of our analysis. Many of the figures contained in the remainder of this section are derived from data contained in that table. Figure 6.1-1 is a histogram showing the distribution of cruise altitudes for these 4,912 flights in the baseline scenario.

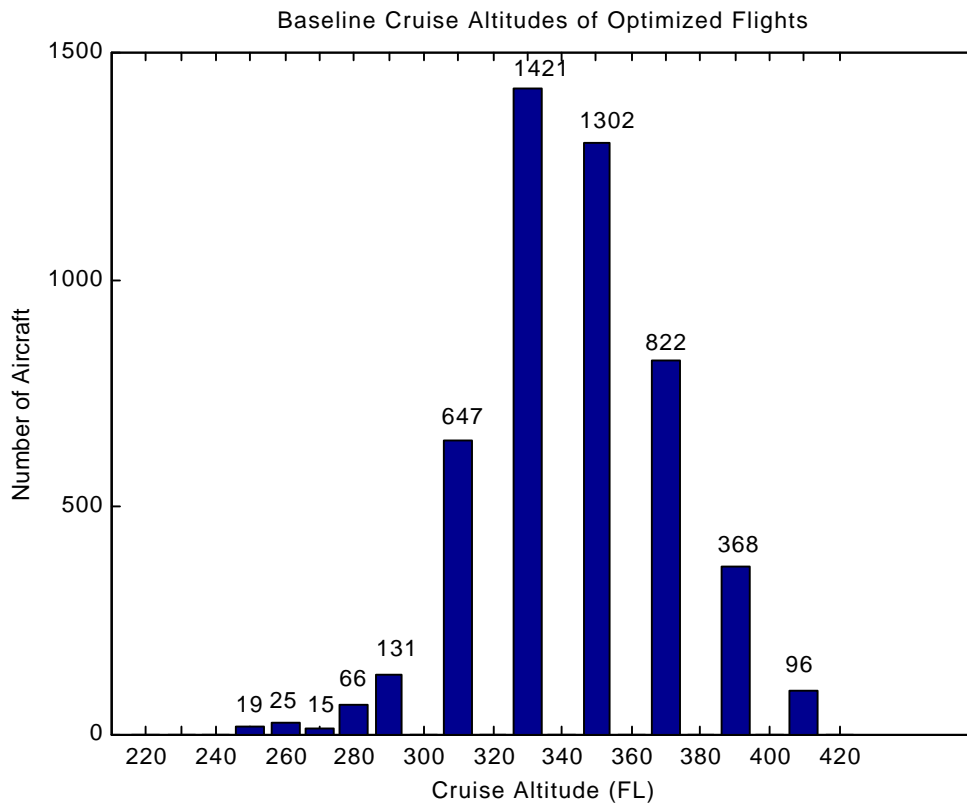


Figure 6.1-1 Cruise Altitude Distribution of Candidate Flights - Baseline

Figure 6.1-2 presents the corresponding histogram for the first domestic RVSM implementation option considered in this study (i.e., FL 350-410). Figure 6.1-3 presents a histogram of stage lengths for the scenario flights (i.e., 4912 flights).



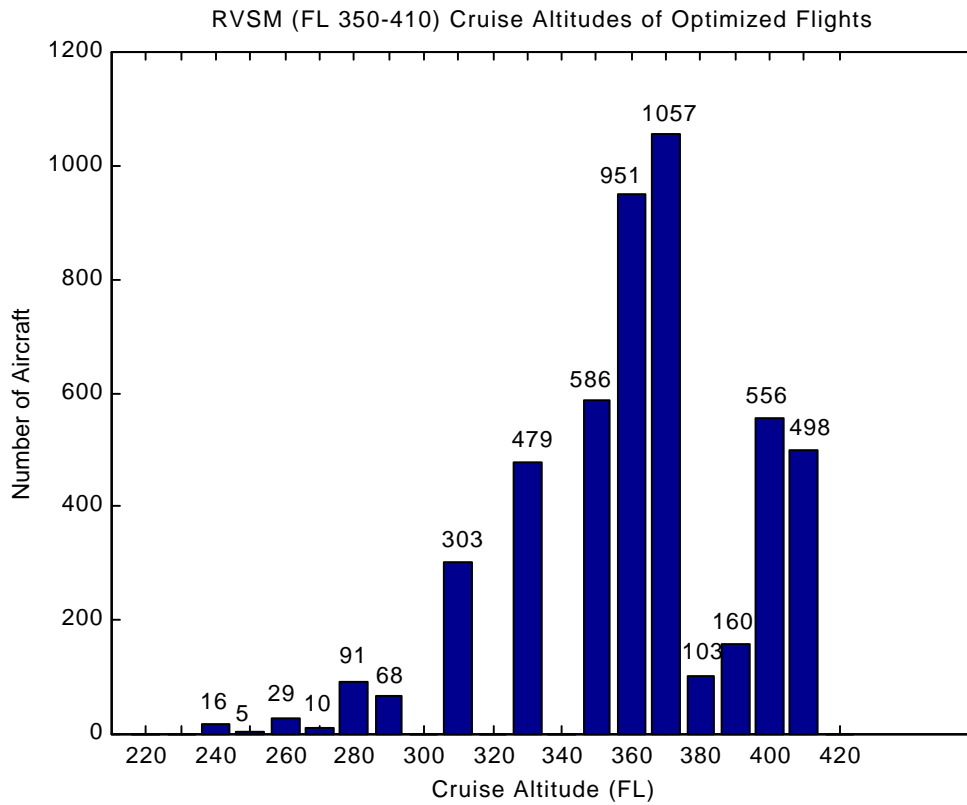


Figure 6.1-2 Cruise Altitude Distribution of Candidate Flights – RVSM Implementation Option #1 ((FL350 – FL410)



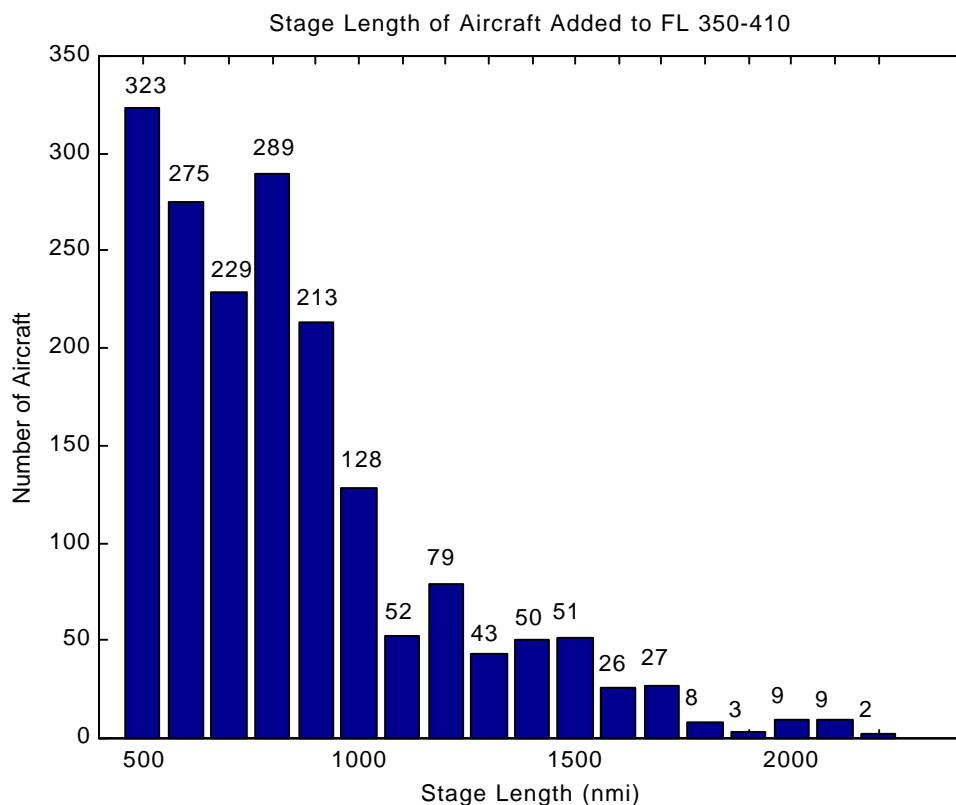


Figure 6.1-3 Flight Stage Length Distribution of Candidate Flights

Figure 6.1-4 shows the distribution of cruise altitude changes for the flights affected by implementing RVSM in FL 350-410. As shown in this figure, the majority of flights were either unchanged or were increased in altitude between 1000 and 5000 feet. This figure also shows cases in which aircraft were moved below their original flight levels are described later in this report. These cases are further discussed later in this section.



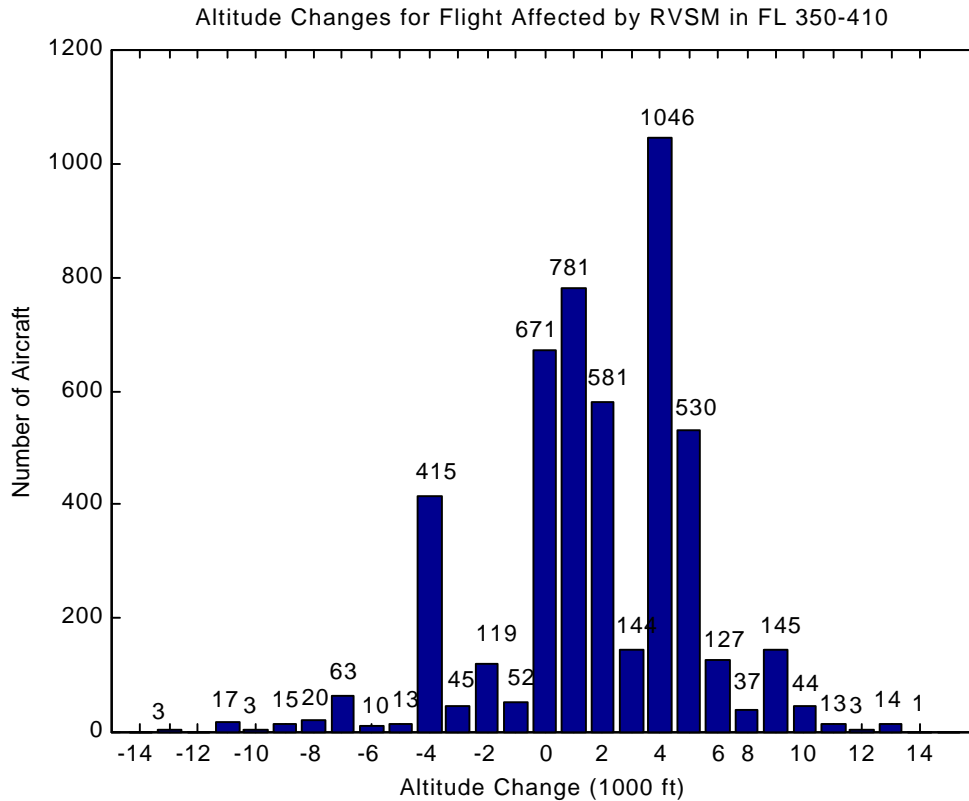


Figure 6.1-4 Flight Level Changes Due to RVMS Implementation – RVSM Implementation Option #1 ((FL350 – FL410)

Figure 6.1-5 shows the change in traffic count within the RVSM altitude band (FL350 – FL410) over the course of the scenario day. The trend is a consistent increase in traffic as compared to the baseline scenario. The maximum hourly increase is 331 flights and the minimum hourly increase is 28 aircraft. For the case of the second implementation option (FL 370-410) the maximum hourly increase was 263 flights and the minimum hourly increase was 16 aircraft.



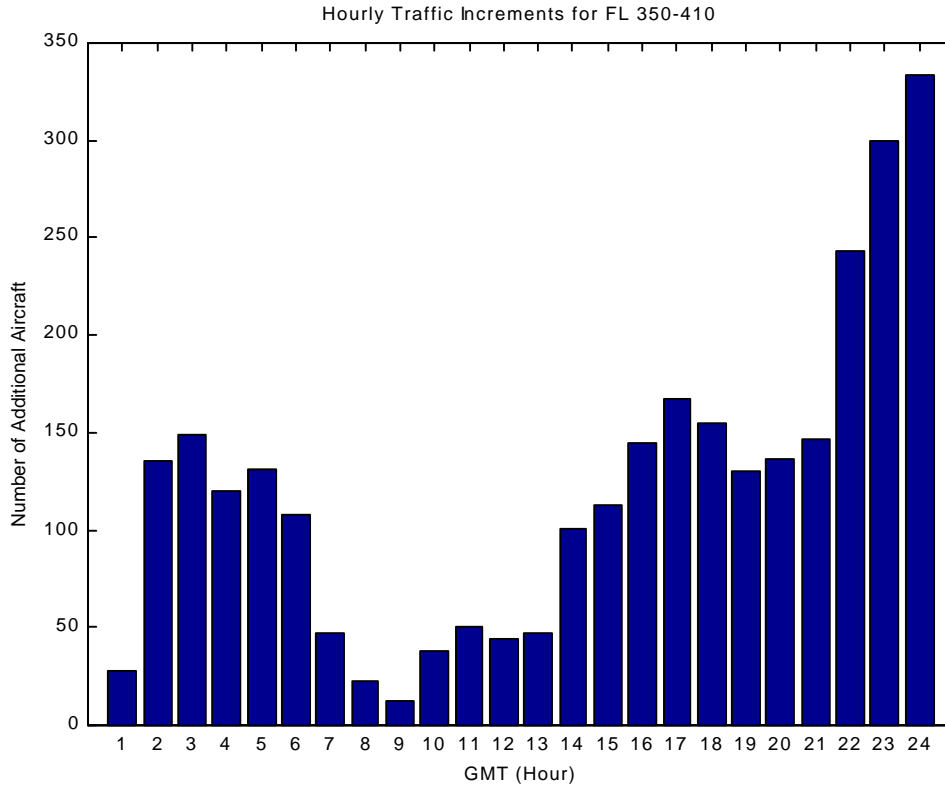


Figure 6.1-5 Hourly Change in Traffic Count – RVSM Implementation Option #1 (FL350 – FL410)

Table 6.1-1 summarizes the changes in traffic distribution within the RVSM altitude bands for the two domestic RVSM implementation alternatives. The total number of aircraft optimized was 4,912 for both cases. For the first implementation option (FL 350-410) 492 flights were moved beneath the RVSM bands and 272 were moved out and lower for the second implementation option (FL 370-410). Of these lowered flights, 288 or 59% (implementation option #1) and 195 or 72% (implementation option #2) were moved due to favorable winds and thus experienced a reduction in fuel-burn as compared to the baseline. The remainder of the aircraft that were moved below the RVSM band (i.e., FL350 – FL410 or FL370 – FL410) experienced additional fuel burn flying at lower altitudes. This result could at least partially be attributed to uncertainties in load factors for particular flights. If the load factor used for optimization was larger than what a flight actually experienced, the result of the optimization might be that the heavier flight could not cruise at as high an altitude as the lighter flight actually did.



Table 6.1-1 Aircraft Altitude Changes

Aircraft Behavior	RVSM FL 350-410	RVSM FL 370-410
Remained Within RVSM Band	2,095	1,014
Remained Below RVSM Band	509	2,266
Moved Into RVSM Band (Up)	1,816	1,360
Moved Out of RVSM Band (Below)	492	272
Total	4,912	4,912

Table 6.1-2 provides traffic counts for the 20 domestic en route Centers. To provide a better indication of the operational impacts of domestic RVSM introduction, the maximum hourly counts for each Center were determined for the baseline and both RVSM scenarios. With the exception of one case, the maximum hourly aircraft count within the flight band considered increased with RVSM introduction. However, the increase in maximum hourly count is only an operational impact if aircraft move from one sector to another (i.e., high sector to ultra-high sector), not merely change altitudes within the sector. Access to Standard Operating Procedures for all Centers would be required to obtain the detailed geographic data (i.e., sector floor and ceiling) necessary to perform this analysis. To attempt to gauge the magnitude of this impact we used a somewhat less-detailed database of sector boundaries. This database indicated that ultra-high sectors within ZME, ZID and ZTL all begin at FL350. Based upon this data, the effect of domestic RVSM implementation in these Centers would be an increase in the traffic handled by ultra-high sectors. The increase in maximum hourly count within the flight band of FL350-FL410 for ZME, ZID and ZTL was calculated as 14.5%, 13.5% and 23% respectively.



Table 6.1-2 Traffic Counts Within Impacted Altitude Bands

ARTCC	Aircraft within FL 350-410 Baseline (per day)	Max Hourly Count within FL 350-410 (Baseline)	Max Hourly Count within FL 350-410 (Option1)	Aircraft within FL 370-410 Baseline (per day)	Max Hourly Count within FL 370-410 (Baseline)	Max Hourly Count within FL 370-410 (Option 2)
ZAB	979	124	166	538	82	115
ZAU	1343	130	131	727	80	81
ZBW	638	67	66	255	26	27
ZDC	1150	123	165	500	48	76
ZDV	1515	223	241	920	138	163
ZFW	1048	102	139	588	61	89
ZHU	717	78	82	373	43	46
ZID	1513	148	168	714	65	82
ZJX	1104	132	165	593	62	87
ZKC	1356	150	173	719	86	104
ZLA	1199	117	141	637	80	104
ZLC	842	126	136	501	84	99
ZMA	808	84	101	455	48	60
ZME	1258	145	176	632	77	100
ZMP	1178	131	134	655	84	89
ZNY	958	77	79	340	27	41
ZOA	722	77	94	347	38	53
ZOB	1627	161	164	747	96	91
ZSE	505	61	79	250	35	45
ZTL	1573	165	188	738	73	96

6.2 Fuel Savings

The fuel savings associated with domestic RVMS implementation was calculated to be 5,136,300 pounds for the scenario day for the first implementation option (FL350 – FL410). The corresponding fuel savings for the second implementation option was calculated to be 4,448,700 pounds. For the 4,912 flights considered, the daily savings associated with the two implementation alternatives was \$389,120 (FL350 – FL410) and \$337,030 (FL370 – FL410). These savings were calculated based upon an average domestic price of jet fuel of \$0.50 per gallon.

It is important to note that due to the analysis methodology used, the benefits above include benefits that are not directly attributable to RVSM. For example, OPGEN was used to generate RVSM scenarios and no attempt was made to model actual flight profiles or operational procedures applied by controllers due to their site-specific nature.



7 Conclusions and Recommendations

The total daily fuel savings attributable to domestic RVSM implementation within the altitude band of FL350 – FL410 was approximately \$390,000. This savings corresponds to 8.3% of the total fuel used by the affected flights (approximately 5,000 flights). The additional number of aircraft-hours flown within this flight band was 1,448 which corresponds to an increase of 12.8% when compared with the baseline scenario which included 9430 flights within this altitude band. For the second RVSM implementation option considered (FL370 – FL410), the corresponding fuel savings was approximately \$340,000 for the scenario day. The additional number of aircraft-hours flown within this flight band was 1,405 which corresponds to a 23.3% increase from the baseline which contained 4727 flights within this altitude band.

It is important to note that these benefits include benefits above and beyond RVSM implementation, specifically improved flight profiles and operational constraints. Further research is required to quantify the contribution of these factors so that a more accurate assessment of the benefits of domestic RVSM implementation may be estimated.



8 References

1. CSSI, Inc., “National Airspace Resource Investment Model (NARIM, User Guide,” Version 1.1, January 1998.
2. CSSI, Inc., “OPGEN-RING, User Manual,” Issue 1.0.
3. Clifford H. Dey, NCEP Central Operations, “The WMO Format For The Storage Of Weather Product Information And The Exchange Of Weather Product Messages In Gridded Binary Form”, January 2, 1996.
4. Program Management Branch, AFS-200, “Master Minimum Equipment List (MMEL) For Reduced Vertical Separation Minimum (RVSM) Operations”, Policy Letter 84, Revision 1, August 15, 1997.



Appendix A Load Factor Data

From	To	DOT Eqpt Code	Yr	Mo	Avg. Stage Length	Departures	O/B Pax	Seats Available	ASM'S (000's)	RPM'S (000's)	Load Fac(%)	A/C Name
ABQ	DAL	6161	99	3	580	10	926	1220	708	537	76	737-500 B
ABQ	DAL	6191	99	3	580	148	16782	20276	11760	9734	83	737-300
ABQ	DAL	6201	99	3	580	58	4903	7076	4104	2844	69	737-1/200
ABQ	DEN	6191	99	3	349	37	3412	4684	1635	1191	73	737-300
ABQ	DEN	6201	99	3	349	59	3520	6438	2247	1228	55	737-1/200
ABQ	DEN	6221	99	3	349	117	9103	21996	7677	3177	41	757-200
ABQ	DEN	7151	99	3	349	103	9313	15141	5284	3250	62	727-200
ABQ	DFW	6551	99	3	569	241	26022	33585	19110	14807	77	MD-80/DC-9
ABQ	LAS	6161	99	3	487	2	122	244	119	59	50	737-500 B
ABQ	LAS	6191	99	3	487	177	17318	24249	11809	8434	71	737-300
ABQ	LAS	6261	99	3	487	1	252	252	123	123	100	767-300
ABQ	LAX	6161	99	3	677	19	1274	2318	1569	862	55	737-500 B
ABQ	LAX	6191	99	3	677	190	18925	26021	17616	12812	73	737-300
ABQ	LAX	6201	99	3	677	1	56	122	83	38	46	737-1/200
ABQ	LAX	7301	99	3	677	1	124	297	201	84	42	DC-10-10
ABQ	PHX	6161	99	3	328	28	2345	3416	1120	769	69	737-500 B
ABQ	PHX	6191	99	3	328	486	43123	65970	21638	14144	65	737-300
ABQ	PHX	6201	99	3	328	43	3879	4922	1614	1272	79	737-1/200
ABQ	PHX	6221	99	3	328	23	1856	4366	1432	609	43	757-200
ABQ	PHX	6941	99	3	328	6	417	900	295	137	46	A320 1/200
ABQ	PHX	6981	99	3	328	2	78	248	81	26	31	A319 Airbu
ABQ	STL	6191	99	3	934	61	5800	8357	7805	5417	69	737-300
ABQ	STL	6551	99	3	934	151	15319	21310	19904	14308	72	MD-80/DC-9
ANC	FAI	6171	99	3	261	90	6582	12600	3289	1718	52	737-400 B
ANC	FAI	6211	99	3	261	12	994	1332	348	259	75	737-200C
ANC	FAI	6213	99	3	261	57	2272	3126	816	593	73	737-200C



Appendix B Wind Data

This Appendix discusses the steps followed to identify candidate scenario days to support the analysis of domestic RVSM implementation. Gridded wind data was necessary to support our comparison of days but was not readily available for previous days. As such, the first step necessary was to identify sources of gridded wind data and determine what data was available from each source.

San Francisco State University archives infrared satellite images and 300 Mb jet stream analysis (AVN model) for the most recent four weeks. These archives are available from the University's web site located at <http://virga.sfsu.edu/jetstream>. However, this source provides data for a single altitude and provides no quantitative data. Figure B-1 shows a sample image for September 8, 1999.

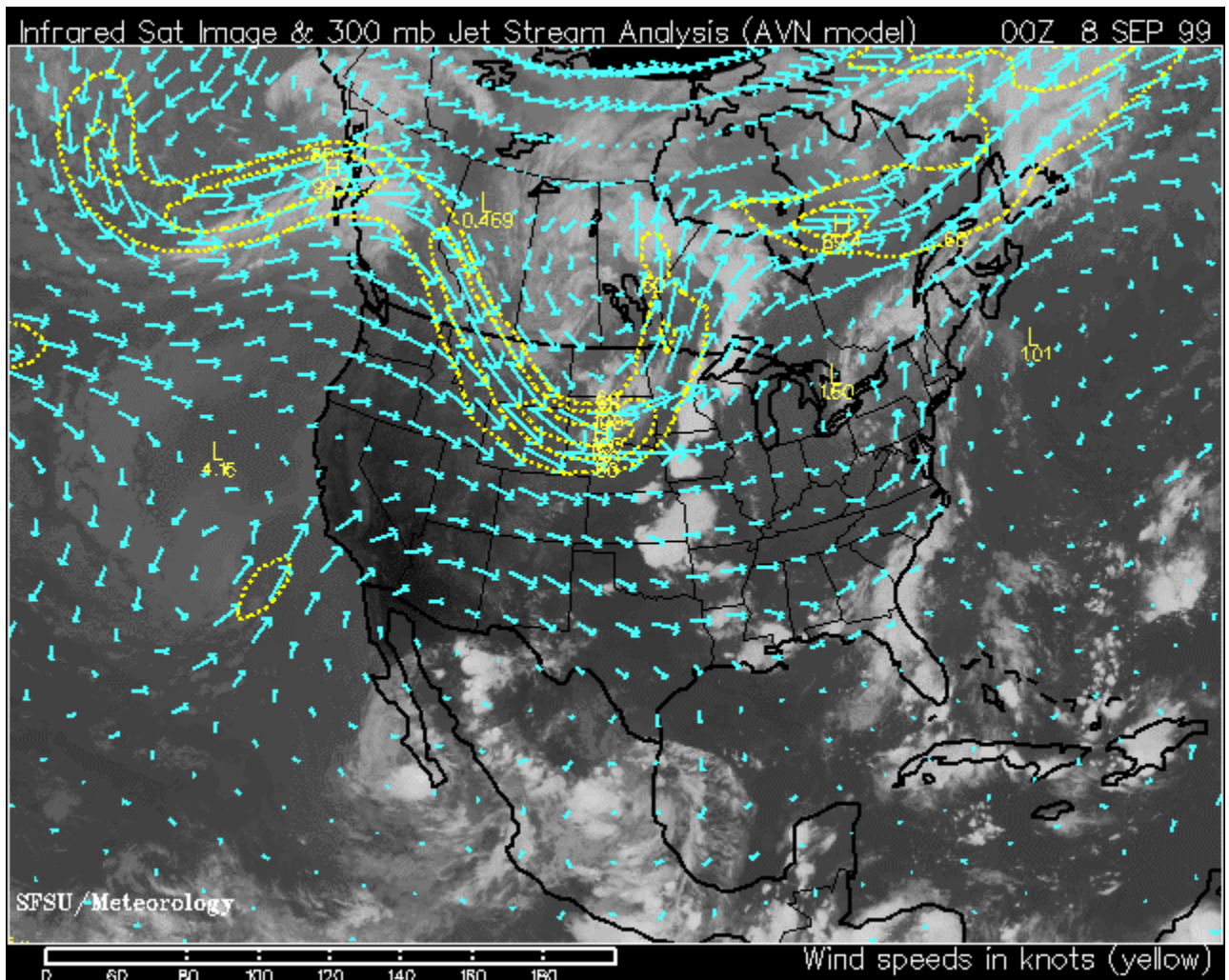


Figure B-1 Infrared Satellite Image & 300 Mb Jet Stream Analysis (AVN model)

AVN model data in GRIB (i.e, gridded binary) format [3] is available for the two most recent days from the National Centers for Environmental Prediction (NCEP) of National



Oceanic and Atmospheric Administration (NOAA). This data is accessible through their ftp site located at <ftp://ftp.ncep.noaa.gov>.

The AVN model data uses Global Grid (i.e. 65160-point (360x181) global longitude-latitude grid with a 1.0-degree increment). (1,1) at 0E, 90N. NOAA provides a Wgrib utility used to extract wind data from the GRIB data for different pressure levels (total of 26). Table B-1 shows extracted pressure levels (in Mb) with corresponding altitudes (in feet).

Table B-1 Pressure Levels and Corresponding Altitudes

Level (#)	Pressure (Mb)	Altitude (ft)
1	1,000	363
2	975	1,060
3	950	1,772
4	925	2,498
5	900	3,241
6	850	4,779
7	800	6,391
8	750	8,087
9	700	9,878
10	650	11,775
11	600	13,794
12	550	15,955
13	500	18,281
14	450	20,803
15	400	23,564
16	350	26,620
17	300	30,052
18	250	33,984
19	200	38,615
20	150	44,301
21	100	51,806
22	70	57,945
23	50	63,366
24	30	70,962
25	20	76,487
26	10	84,988

The extracted results contain horizontal (u) and vertical (v) wind components. Figure B-2 shows wind speed vectors plotted for a pressure level of 300 Mb for September 8, 1999 (0:00 Zulu). From this plot one can visually identify the location of the jet stream (i.e., by observing the highest speed magnitude vectors). These results appear consistent with those shown on Figure B-1.



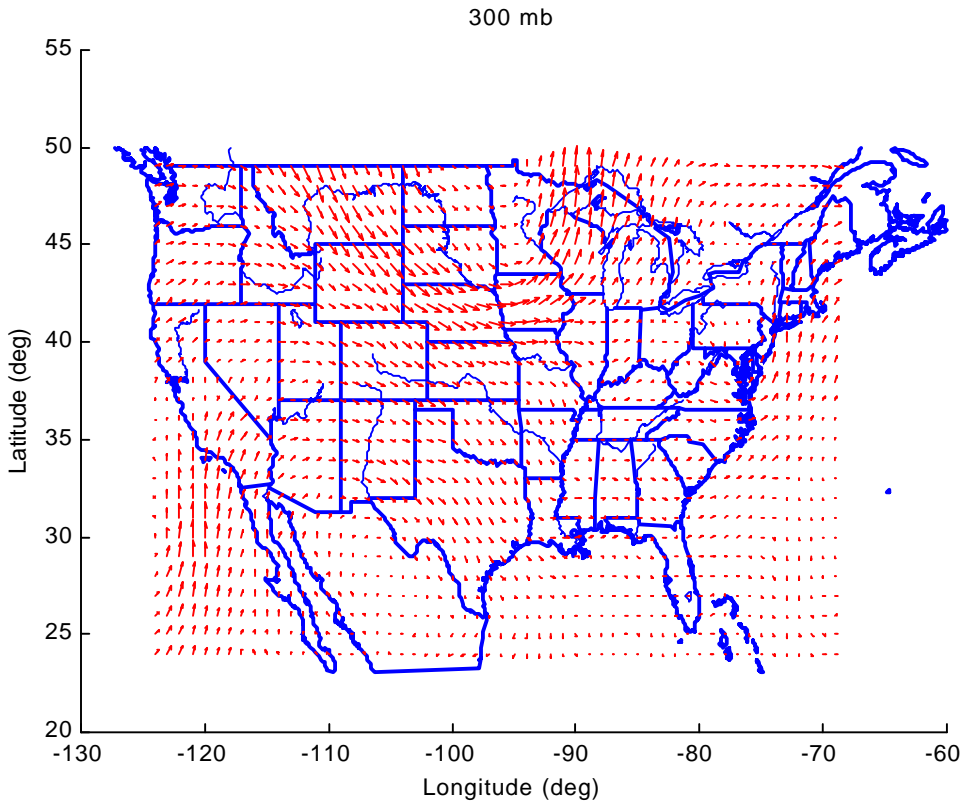


Figure B-2 300 Mb Wind Speeds

To identify the vertical location of the jet stream (i.e., the altitude that it occurs at) and its depth, it is necessary to calculate the average speed along the jet for different altitudes using the following formula:

$$\bar{V}(h) = \frac{\int V(h) dl}{\int dl}$$

Where:

$$V = \sqrt{u^2 + v^2}$$

Sample results of this analysis for Figure B-2 are shown on Figure B-3. The wind speed in the jet stream reaches its maximum of 70 knots at an altitude of FL 340. More important is the fact that the velocity doesn't vary significantly throughout the candidate altitude bands (i.e., approximately 62 knots to 70 knots). A cursory analysis of jet streams for additional days in March and September of 1999 showed that the jet stream reached its maximum velocity in the altitude band of FL 320-360. The variation in velocity was less than 15 knots throughout the candidate RVSM altitude bands (i.e., FL350 – FL410).



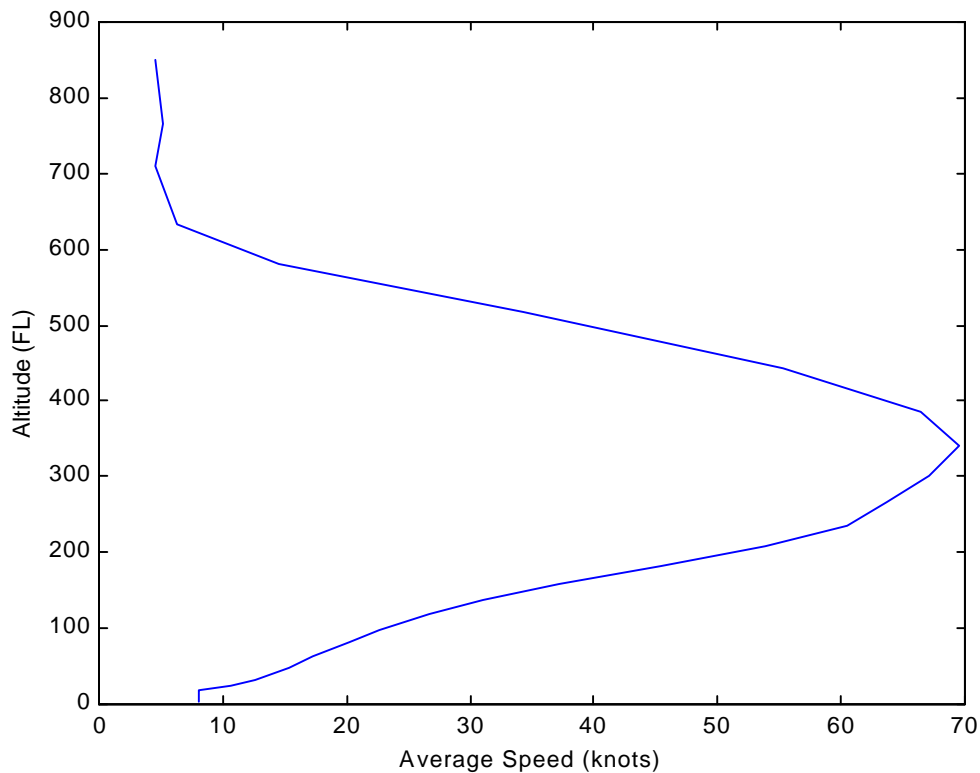


Figure B-3 Jet Stream Vertical Profile

Since March 1999 was the most recent airline load factor data available, archived weather data for March 1999 was ordered from the Scientific Computing Division of the National Center for Atmospheric Research (NCAR). This data is similar to that previously described with the exception that the grid increment is 2.5 degrees and only 16 pressure levels (vs. the original 26) are included. These pressure levels are: 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, and 10 Mb. Corresponding altitudes for these pressure levels are shown in Table B-1.



Appendix C Aircraft Types

Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
A10	Fairchild Industries (USA)	61	Thunderbolt II	m	✓	✓	1	✓	1			Y
A300	Airbus Industries (International)	3	A300B2	c	✓							✓
A306	Airbus Industries (International)	127	A300B4-600	c	✓	✓	31	✓	1			✓
A30B	Airbus Industries (International)	4	A300B2	c	✓							✓
A310	Airbus Industries (International)	95	A310	c	✓	✓	34	✓	12			✓
A319	Airbus Industries (International)	220	A319	c	✓	✓	168	✓	133			✓
A320	Airbus Industries (International)	570	A320	c	✓	✓	436	✓	289			✓
A321	Airbus Industries (International)	5	A321	c	✓	✓	5	✓	3			✓
A330	Airbus Industries (International)	13	A330	c	✓	✓	9	✓	9			✓
A340	Airbus Industries (International)	31	A340	c	✓	✓	24	✓	18			✓
A748	British Aerospace (Bae) (UK)	7	BAe HS 748 (Andover, C-91)	c								
AA5	Grumman Airspace Corp. (USA)	15	Cheetah AA-5/A/B	c								
AC11	Rockwell International Corp. (USA)	4		c								
AC50	Rockwell International Corp. (USA)	26	Commander 500	c								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
AC6	Rockwell International Corp. (USA)	1		c								
AC68	Rockwell International Corp. (USA)	6	Super Commander 680S	c								
AC69	Rockwell International Corp. (USA)	8	Jet Prop Commander	c								
AC6L	Rockwell International Corp. (USA)	1		c								
AC6T	Rockwell International Corp. (USA)	15	Turbo Commander 690C	c								
AC70	Rockwell International Corp. (USA)	1		c								
AC80	Rockwell International Corp. (USA)	1		c								
AC90	Rockwell International Corp. (USA)	24		c	✓							
AC95	Rockwell International Corp. (USA)	2	Aero Commander 695	c								
AEST	Piper Aircraft Corp. (USA)	25	Aero Star 600/700	c								
ASTR	Israel Aircraft Industries & Astra Jet (Israel/USA)	29		c	✓	✓	18	✓	16	✓	1	✓
AT38	Aerospatiale/Aeritalia (France/Italy)	1		c	✓							



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
AT42	Aerospatiale/Aeritalia (France/Italy)	171	ATR 42-200/300	c								
AT43	Aerospatiale/Aeritalia (France/Italy)	262	ATR 42-200/300/320	c								
AT45	Aerospatiale/Aeritalia (France/Italy)	51	ATR 42-500	c								
AT72	Aerospatiale/Aeritalia (France/Italy)	352	ATR 72	c								
B1	Rockwell International Corp. (USA)	23	Lancer	m	✓							
B190	Beech Aircraft Company (USA)	1474	Beech 1900/C-12J	c	✓							
B25B	Rockwell International Corp. (USA)	1	Mitchell	m	✓							
B35	Beech Aircraft Company (USA)	1	Bonanza 35	c	✓							
B350	Beech Aircraft Company (USA)	45	Super King Air 350	c	✓							
B52	Boeing Company (USA)	12	Stratofortress	m	✓							
B58	Beech Aircraft Company (USA)	2	Baron 58, Foxstar	c	✓							
B703	Boeing Company (USA)	1	707 Series	c	✓							
B707	Boeing Company (USA)	4	707 Series	c	✓							
B720	Boeing Company (USA)	1	720/B	c	✓					✓	1	
B721	Boeing Company (USA)	154	727 Series	c	✓	✓	28	✓	6			✓
B722	Boeing Company (USA)	924	727 Series	c	✓	✓	257	✓	69	✓	1	✓



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
B727	Boeing Company (USA)	57	727 Series	c	✓	✓	8	✓	3			✓
B72Q	Boeing Company (USA)	637	727 Series	c	✓	✓	167	✓	43			✓
B731	Boeing Company (USA)	6	737 Series	c	✓							✓
B732	Boeing Company (USA)	633	737 Series	c	✓	✓	168	✓	25			✓
B733	Boeing Company (USA)	1862	737 Series	c	✓	✓	963	✓	361	✓	1	✓
B734	Boeing Company (USA)	372	737 Series	c	✓	✓	141	✓	36			✓
B735	Boeing Company (USA)	582	737 Series	c	✓	✓	319	✓	139			✓
B737	Boeing Company (USA)	205	737 Series	c	✓	✓	126	✓	105			✓
B738	Boeing Company (USA)	79	737 Series	c	✓	✓	49	✓	28			✓
B73A	Boeing Company (USA)	35	737 Series	c	✓	✓	17	✓	7			✓
B73B	Boeing Company (USA)	18	737 Series	c	✓	✓	18	✓	9			✓
B73C	Boeing Company (USA)	5	737 Series	c	✓			✓	3			✓
B73F	Boeing Company (USA)	1	737 Series	c	✓							✓
B73Q	Boeing Company (USA)	397	737 Series	c	✓	✓	107	✓	13			✓
B73S	Boeing Company (USA)	2	737 Series	c	✓	✓	1					✓
B741	Boeing Company (USA)	36	747 Series	c	✓	✓	20	✓	8			✓
B742	Boeing Company (USA)	78	747 Series	c	✓	✓	44	✓	20			✓



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
B743	Boeing Company (USA)	14	747 Series	c	✓	✓	5					✓
B744	Boeing Company (USA)	102	747 Series	c	✓	✓	59	✓	34			✓
B747	Boeing Company (USA)	5	747 Series	c	✓	✓	3	✓	2			✓
B74A	Boeing Company (USA)	1	747 Series	c	✓	✓	1					✓
B74B	Boeing Company (USA)	1	747 Series	c	✓							✓
B752	Boeing Company (USA)	1275	757 Series	c	✓	✓	1024	✓	810			✓
B757	Boeing Company (USA)	3	757 Series	c	✓	✓	3	✓	1			✓
B762	Boeing Company (USA)	216	767 Series	c	✓	✓	182	✓	158			✓
B763	Boeing Company (USA)	331	767 Series	c	✓	✓	220	✓	147			✓
B767	Boeing Company (USA)	2	767 Series	c	✓	✓	1					✓
B772	Boeing Company (USA)	61	777 Series	c	✓	✓	51	✓	45			✓
BA10	Britten Norman Ltd. (UK)	2	VC-10	c								
BA11	British Aerospace (Bae) (UK)	2	BAC One-Eleven	c	✓	✓	1					N
BA31	British Aerospace (Bae) (UK)	2	BAe Jetstream 31	c								
BA36	British Aerospace (Bae) (UK)	1		c								
BA46	British Aerospace (Bae) (UK)	227	BAe 146-100/200 Series	c	✓	✓	1					N
BATP	British Aerospace (Bae) (UK)	49	Advance Turboprop (ATP)	c								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
BE02	Beech Aircraft Company (USA)	13	Beech 1900/C	c								
BE10	Beech Aircraft Company (USA)	113	King Air 100/A	c								
BE18	Beech Aircraft Company (USA)	37	Twin Beech 18	c								
BE19	Beech Aircraft Company (USA)	4	Sport 19	c								
BE20	Beech Aircraft Company (USA)	372	Super King Air 200, Huron	c	✓	✓	1					N
BE23	Beech Aircraft Company (USA)	4	Sundowner 23, Musketeer 23	c								
BE24	Beech Aircraft Company (USA)	3	Sierra 24	c								
BE30	Beech Aircraft Company (USA)	31	Supper King Air 300	c	✓							
BE33	Beech Aircraft Company (USA)	22	Bonanza 33	c								
BE35	Beech Aircraft Company (USA)	52	Bonanza 35	c								
BE36	Beech Aircraft Company (USA)	102	Bonanza 36	c								
BE3B	Beech Aircraft Company (USA)	3	Super King Air 350	c								
BE40	Beech Aircraft Company (USA)	208		c	✓	✓	63	✓	49	✓	2	Y
BE46	Beech Aircraft Company (USA)	1		c								
BE50	Beech Aircraft Company (USA)	1	Twin Bonanza 50	c								
BE55	Beech Aircraft Company (USA)	65	Baron 55/Chochise	c								
BE56	Beech Aircraft Company (USA)	1		c								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
BE58	Beech Aircraft Company (USA)	266	Baron 58	c	✓							
BE60	Beech Aircraft Company (USA)	11	Duke 60	c								
BE65	Beech Aircraft Company (USA)	3	Queen Air 65/A65/70	c								
BE76	Beech Aircraft Company (USA)	22	Duchess 76	c								
BE80	Beech Aircraft Company (USA)	21	Queen Air 80	c								
BE8T	Beech Aircraft Company (USA)	2		c								
BE90	Beech Aircraft Company (USA)	57	King Air C90, E90	c								
BE95	Beech Aircraft Company (USA)	13	Travelair 95	c								
BE99	Beech Aircraft Company (USA)	121	Airliner/Model 99	c								
BE9F	Beech Aircraft Company (USA)	1	Beech F90	c								
BE9L	Beech Aircraft Company (USA)	170		c								
BE9L	Beech Aircraft Company (USA)	5	King Air 90, A90 to E90, Taurus 90	c								
BE9O	Beech Aircraft Company (USA)	1		c								
BE9T	Beech Aircraft Company (USA)	18		c								
BL17	Bellanca Aircraft (USA)	5		c								
BL26	Bellanca Aircraft (USA)	1	Model 17-30A, Super Viking 300A	c								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
BN2	Britten Norman Ltd. (UK)	1	BN-2A/B Islander	c								
C12	Beech Aircraft Company (USA)	3	Super King Air 200, Huron	m								
C130	Lockheed Corp. (USA)	123	C-130 Hercules	m	✓	✓	1	✓	1			N
C135	Boeing Company (USA)	22	Stratolifter B717	m	✓	✓	2					N
C141	Lockheed Corp. (USA)	29	C-141 Starlifter	m	✓	✓	11	✓	5			Y
C150	Cessna Aircraft Company (USA)	2	Cessna 150	c								
C152	Cessna Aircraft Company (USA)	9	Cessna 152	c								
C160	Nord Aviation (Affiliate of Aerospatiale) (France)	2	Transall C-160	c								
C17	McDonnell-Douglas Corp. (USA)	13	Globemaster 3	m	✓	✓	1					N
C170	Cessna Aircraft Company (USA)	1		c								
C172	Cessna Aircraft Company (USA)	169	Skyhawk 172	c								
C177	Cessna Aircraft Company (USA)	13		c								
C180	Cessna Aircraft Company (USA)	4	Skywagon 180	c								
C182	Cessna Aircraft Company (USA)	80		c								
C185	Cessna Aircraft Company (USA)	5	Skywagon 185	c								
C2	Grumman Airspace Corp. (USA)	2	Greyhound	m								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
C205	Cessna Aircraft Company (USA)	1	Super Skywagon/Super Skyline	c								
C206	Cessna Aircraft Company (USA)	11	Stationair 6, Turbo Stationair 6	c								
C207	Cessna Aircraft Company (USA)	1	Stationair/Turbo Stationair 7/8	c								
C208	Cessna Aircraft Company (USA)	488	Caravan I 208A	c								
C210	Cessna Aircraft Company (USA)	123	Centurion/II	c	✓							
C212	Construcciones Aeronauticas (CASA) (Spain)	5	C-212 Aviocar	c								
C303	Cessna Aircraft Company (USA)	6	Crusader 303	c								
C310	Cessna Aircraft Company (USA)	126	Cessna 310	c								
C320	Cessna Aircraft Company (USA)	5	Skynight 320	c								
C335	Cessna Aircraft Company (USA)	2	Cessna 335	c								
C337	Cessna Aircraft Company (USA)	12	Super Skymaster 337	c								
C340	Cessna Aircraft Company (USA)	82	Cessna 340	c								
C401	Cessna Aircraft Company (USA)	32	Cessna 401	c								
C402	Cessna Aircraft Company (USA)	148	Cessna 402	c								
C404	Cessna Aircraft Company (USA)	18	Titan 404	c								
C406	Cessna Aircraft Company (USA)	1		c								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
C414	Cessna Aircraft Company (USA)	86	Chancellor 414	c								
C421	Cessna Aircraft Company (USA)	117	Golden Eagle 421	c								
C425	Cessna Aircraft Company (USA)	38	Corsair/Conquest I-425	c								
C441	Cessna Aircraft Company (USA)	55	Conquest/II-441	c	✓	✓	1					N
C5	Lockheed Corp. (USA)	14	C-5 Galaxy	m	✓	✓	3	✓	2			Y
C500	Cessna Aircraft Company (USA)	63	Citation I	c	✓	✓	15	✓	9			Y
C501	Cessna Aircraft Company (USA)	39	Citation I-SP	c	✓	✓	8	✓	6			Y
C525	Cessna Aircraft Company (USA)	65		c	✓	✓	25	✓	15			Y
C550	Cessna Aircraft Company (USA)	230	Citation II-S2	c	✓	✓	84	✓	54	✓	3	Y
C551	Cessna Aircraft Company (USA)	5	Citation II-SP	c	✓	✓	1					Y
C560	Cessna Aircraft Company (USA)	201	Citation V	c	✓	✓	123	✓	110	✓	9	Y
C56X	Cessna Aircraft Company (USA)	2		c	✓	✓	2	✓	2			Y
C650	Cessna Aircraft Company (USA)	115	Citation III	c	✓	✓	80	✓	69	✓	12	✓
C65C	Cessna Aircraft Company (USA)	1		c								
C712	Cessna Aircraft Company (USA)	1		c								
C72R	Cessna Aircraft Company (USA)	5	Cutlass RG, 172 RG	c	✓	✓	1	✓	1			Y
C750	Cessna Aircraft Company (USA)	41	Citation 10	c	✓	✓	14	✓	12	✓	16	✓



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
C82R	Cessna Aircraft Company (USA)	7	Skylane RG, Turbo Skylane RG	c								
C9	McDonnell-Douglas Corp. (USA)	9	DC-9 series	m	✓	✓	4					Y
C9Q		10	DC-9 series	m	✓	✓	2					Y
CARJ	Canadair Bombardier Ltd. (Canada)	1069	Regional Jet	c	✓	✓	123	✓	19	✓	1	Y
CH7A	Bellanca Aircraft (USA)	1	Champion 7, Citabria, Traveler	c								
CL41	Canadair Bombardier Ltd. (Canada)	11		c								
CL60	Canadair Bombardier Ltd. (Canada)	119	CL600/610 Challenger	c	✓	✓	81	✓	62			✓
CL64	Canadair Bombardier Ltd. (Canada)	22		c	✓	✓	18	✓	14			✓
CL65	Canadair Bombardier Ltd. (Canada)	18	Regional Jet	c	✓	✓	8					✓
CM11	Camair Aircraft Corp. (USA)	3		c								
CONC	Aerospatiale/British Aerospace (France/UK)	3	Concorde	c	✓					✓	3	
CV24	General Dynamics Corp. (USA)	4	Convair 240	c								
CV34	General Dynamics Corp. (USA)	1	Convair 340, Liner, Samaritan	c								
CV58	General Dynamics Corp. (USA)	4	Convair 580	c								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
CVLP	General Dynamics Corp. (USA)	3	Convair 240/340/440	c								
CVLT	General Dynamics Corp. (USA)	52	Convair 540/580/600/640	c								
D228	Dornier GmbH (FRG)	1	Do 228-100/200 Series	c								
D328	Dornier GmbH (FRG)	191	Do 328 Series	c	✓							
DC10	McDonnell-Douglas Corp. (USA)	249	DC-10 series	c	✓	✓	115	✓	46			✓
DC3	McDonnell-Douglas Corp. (USA)	14	Skytrain	c								
DC3F	McDonnell-Douglas Corp. (USA)	1		c								
DC6	McDonnell-Douglas Corp. (USA)	1	DC-6/B Liftmaster	c								
DC8	McDonnell-Douglas Corp. (USA)	2	DC-8 series	c	✓	✓	1	✓	1			Y
DC85	McDonnell-Douglas Corp. (USA)	24	DC-8 series	c	✓	✓	12	✓	7			Y
DC86	McDonnell-Douglas Corp. (USA)	93	DC-8 series	c	✓	✓	30	✓	15			Y
DC87	McDonnell-Douglas Corp. (USA)	79	DC-8 series	c	✓	✓	40	✓	17			Y
DC8Q	McDonnell-Douglas Corp. (USA)	141	DC-8 series	c	✓	✓	71	✓	29			Y
DC8S	McDonnell-Douglas Corp. (USA)	5	Super DC-8 series	c	✓	✓	2					Y
DC9	McDonnell-Douglas Corp. (USA)	855	DC-9 series	c	✓	✓	207	✓	1			Y
DC9Q	McDonnell-Douglas Corp. (USA)	760	DC-9 series	c	✓	✓	241					Y
DH8	Dehavilland (Canada/UK)	81	Dash 8 DHC-8	c	✓							



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
DH8A	Dehavilland (Canada/UK)	986		c								
DH8B	Dehavilland (Canada/UK)	249		c								
DH8C	Dehavilland (Canada/UK)	156		c								
DH8D	Dehavilland (Canada/UK)	1		c								
DHC2	Dehavilland (Canada/UK)	1	Beaver DHC-2	c								
DHC5	Dehavilland (Canada/UK)	1	Buffalo DHC-5D/E	c								
DHC6	Dehavilland (Canada/UK)	8	Twin Otter DHC-6 (all series)	c								
DHC7	Dehavilland (Canada/UK)	14	Dash 7 DHC-7	c								
DHC8	Dehavilland (Canada/UK)	27	Dash 8 DHC-8	c								
E110	Embraer (Brazil)	30	Bandeirante EMB-110	c								
E120	Embraer (Brazil)	1270	Brazilia EMB-120	c	✓							
E2	Grumman Airspace Corp. (USA)	11	Hawkeye	m								
E2C	Grumman Airspace Corp. (USA)	2		m								
E3	Boeing Company (USA)	6	E3 Sentry	m	✓							
E3TF	Boeing Company (USA)	2		m	✓							
E6	Boeing Company (USA)	5	E6 Mercury	m	✓	✓	1					Y
F100	Fokker BV (Netherlands)	472	Fokker 100	c	✓	✓	128					Y



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
F14	Grumman Airspace Corp. (USA)	7	F-14 Tomcat	m	✓	✓	1					Y
F15	McDonnell-Douglas Corp. (USA)	79	F-15 Eagle	m	✓	✓	6	✓	2	✓	2	Y
F16	General Dynamics Corp. (USA)	235	F-16 Fighting Falcon	m	✓	✓	11	✓	6	✓	6	Y
F18	McDonnell-Douglas Corp. (USA)	122	F/A-18 Hornet	m	✓	✓	4	✓	2			Y
F27	Fokker BV (Netherlands)	63	Friendship F27, F227, Troopship	c								
F28	Fokker BV (Netherlands)	270	Fellowship F28	c	✓	✓	2					N
F2TH	Dassault-Breguet (France)	25	Falcon 2000	c	✓	✓	12	✓	12	✓	8	Y
F4	McDonnell-Douglas Corp. (USA)	4	Phantom II	m								
F70	Fokker BV (Netherlands)	3	Fokker 70	c								
F900	Dassault-Breguet (France)	42	Falcon 900, Mystere 900	c	✓	✓	25	✓	20	✓	5	✓
FA10	Dassault-Breguet (France)	53	Falcon 10, Mystere 10	c	✓	✓	24	✓	18			Y
FA18	Dassault-Breguet (France)	5		c	✓	✓	3	✓	2			Y
FA20	Dassault-Breguet (France)	111	Falcon 20, Mystere 20	c	✓	✓	49	✓	23			✓
FA22	Dassault-Breguet (France)	2		c	✓					✓	2	
FA50	Dassault-Breguet (France)	69	Falcon 50, Mystere 50	c	✓	✓	49	✓	38	✓	2	✓
G159	Gulfstream Aerospace Corp. (USA)	9	GAC 159-C, Gulfstream I	c								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
GA7	Grumman Airspace Corp. (USA)	1	Cougar GA-7	c								
GLF2	Gulfstream Aerospace Corp. (USA)	54	Gulfstream II	c	✓	✓	29	✓	27	✓	14	✓
GLF3	Gulfstream Aerospace Corp. (USA)	47	Gulfstream III	c	✓	✓	15	✓	12	✓	19	✓
GLF4	Gulfstream Aerospace Corp. (USA)	91	Gulfstream IV	c	✓	✓	31	✓	25	✓	41	✓
GLF5	Gulfstream Aerospace Corp. (USA)	10		c	✓					✓	9	✓
GULF	Gulfstream Aerospace Corp. (USA)	11		c	✓	✓	4	✓	3	✓	4	✓
H25	British Aerospace (Bae) (UK)	8		c	✓	✓	3	✓	3			Y
H25A	British Aerospace (Bae) (UK)	43	BAe HS 125 Series 1/2/3/400/600	c	✓	✓	22	✓	14			Y
H25B	British Aerospace (Bae) (UK)	141	BAe HS 125 Series 700/800	c	✓	✓	77	✓	55			✓
H25C	British Aerospace (Bae) (UK)	31	BAe HS 125 Series 1000	c	✓	✓	15	✓	14	✓	1	✓
HAR	British Aerospace (Bae) (UK)	3	BAe Harrier	m								
HF32	Hamburger Flugzeugbau (FRG)	2	HFB-320 Hansajet	c	✓	✓	1					N
HS25	British Aerospace (Bae) (UK)	18	Bae HS 125 Series 400/600/700	c	✓	✓	12	✓	7			✓
HS33	British Aerospace (Bae) (UK)	1		c								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
HS74	British Aerospace (Bae) (UK)	1	Bae HS 748 Series 2	c								
IL62	Ilyushin (USSR)	2	IL-62	c	✓	✓	1					N
IL76	Ilyushin (USSR)	1	IL-76/78	c								
JCOM	Rockwell International Corp. (USA)	1	Jet Commander 1121	c	✓	✓	1	✓	1			N
JS31	British Aerospace (Bae) (UK)	110	BAe-3100 Jetsream 31	c								
JS32	British Aerospace (Bae) (UK)	558	BAe-3200 Jetsream Super 31	c								
JS41	British Aerospace (Bae) (UK)	361	BAe-4100 Jetsream 41	c	✓	✓	1	✓	1			N
JSTA	British Aerospace (Bae) (UK)	73		c								
JSTM	British Aerospace (Bae) (UK)	1		c								
KC10	McDonnell-Douglas Corp. (USA)	27	DC-10 (all series)	m	✓	✓	2	✓	1			✓
KE35	Boeing Company (USA)	33	Stratotanker KC-135E	m	✓	✓	6	✓	1			Y
KR35	Boeing Company (USA)	55	Stratotanker KC-135R	m	✓	✓	4					Y
L101	Lockheed Corp. (USA)	112	L-1011 Tri-Star (All Series)	c	✓	✓	71	✓	45			✓
L188	Lockheed Corp. (USA)	4	Electra 188, Model 185/285 Orion	c								
L25	Lockheed Corp. (USA)	1		c	✓					✓	1	
L29A	Lockheed Corp. (USA)	1		c	✓	✓	1	✓	1			Y
L29B	Lockheed Corp. (USA)	10		c	✓	✓	7	✓	4			Y



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
L329	Lockheed Corp. (USA)	2	Model 1329 Jetstar	c	✓	✓	1					
L60	Lockheed Corp. (USA)	1		c								
LJ23	Gates Learjet Corp. (USA)	7	Learjet 23	c	✓	✓	5	✓	5	✓	1	Y
LJ24	Gates Learjet Corp. (USA)	50	Learjet 24	c	✓	✓	32	✓	31	✓	6	Y
LJ25	Gates Learjet Corp. (USA)	101	Learjet 25	c	✓	✓	74	✓	67	✓	6	Y
LJ28	Gates Learjet Corp. (USA)	2	Learjet 28	c	✓						2	Y
LJ31	Gates Learjet Corp. (USA)	59	Learjet 31	c	✓	✓	9	✓	7	✓	29	Y
LJ35	Gates Learjet Corp. (USA)	228	Learjet 35	c	✓	✓	153	✓	133	✓	11	✓
LJ36	Gates Learjet Corp. (USA)	13	Learjet 36	c	✓	✓	9	✓	9	✓	2	✓
LJ41	Gates Learjet Corp. (USA)	1	Learjet 41	c	✓	✓	1	✓	1			Y
LJ45	Gates Learjet Corp. (USA)	7	Learjet 45	c	✓	✓	5	✓	5	✓	1	Y
LJ55	Gates Learjet Corp. (USA)	41	Learjet 55	c	✓	✓	28	✓	25	✓	2	✓
LJ60	Gates Learjet Corp. (USA)	52	Learjet 60	c	✓	✓	36	✓	35	✓	7	✓
M10	Mooney Aircraft Corp. (USA)	1	Mark 10 Cadet	c								
M20	Mooney Aircraft Corp. (USA)	13	M20 Series	c								
M20C	Mooney Aircraft Corp. (USA)	1	M20 Series	c								
M20E	Mooney Aircraft Corp. (USA)	3	M20 Series	c								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
M20J	Mooney Aircraft Corp. (USA)	6	M20 Series	c								
M20K	Mooney Aircraft Corp. (USA)	2	M20 Series	c								
M20M	Mooney Aircraft Corp. (USA)	1	M20 Series	c								
M20P	Mooney Aircraft Corp. (USA)	11	M20 Series	c								
M20R	Mooney Aircraft Corp. (USA)	3	M20 Series	c								
M20T	Mooney Aircraft Corp. (USA)	9	M20 Series	c								
M7	Maule Aircraft Corp. (USA)	1	M-7-235, MT-7, MX-7-160/180/235	c								
MD11	McDonnell-Douglas Corp. (USA)	58		c	✓	✓	31	✓	15			✓
MD80	McDonnell-Douglas Corp. (USA)	1934	DC-9 Super/MD-80 Series	c	✓	✓	617	✓	134			Y
MD82	McDonnell-Douglas Corp. (USA)	16	DC-9 Super/MD-80 Series	c	✓	✓	8	✓	1			Y
MD83	McDonnell-Douglas Corp. (USA)	50	DC-9 Super/MD-80 Series	c	✓	✓	13	✓	2			Y
MD87	McDonnell-Douglas Corp. (USA)	4	DC-9 Super/MD-80 Series	c	✓	✓	1					Y
MD88	McDonnell-Douglas Corp. (USA)	1	DC-9 Super/MD-80 Series	c	✓							
MD90	McDonnell-Douglas Corp. (USA)	73		c	✓	✓	11	✓	2			Y



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
MO20	Mooney Aircraft Corp. (USA)	31	Mark 20	c								
MO2K	Mooney Aircraft Corp. (USA)	1	Turbo Mooney 231/M20K	c								
MU2	Mitsubishi Aircraft International Inc. (USA/Japan)	121	Mitsubishi MU-2	c								
MU3	Mitsubishi Aircraft International Inc. (USA/Japan)	3	Mitsubishi Diamond I/MU-300	c								
MU30	Mitsubishi Aircraft International Inc. (USA/Japan)	22		c	✓	✓	4	✓	1	✓	1	Y
NAVI	Rockwell International Corp. (USA)	1	Navion NA 145/154	c								
P210	Cessna Aircraft Company (USA)	1	Pressurized Centurion	c								
P3	Lockheed Corp. (USA)	40	Electra 188, Model 185/285 Orion	m	✓							
P32R	Piper Aircraft Corp. (USA)	21	Cherokee Lance PA-32R, Saratoga SP	c								
P337	Cessna Aircraft Company (USA)	1	Pressurized Skymaster T337G, P337	c								
P46T	Piper Aircraft Corp. (USA)	1	Malibu Meridian	c	✓							
P68	Partenavia Construzioni Aeronautiche SpA (Italy)	1	P68/B/C/-TC, Victor, Observer/P68R	c	✓							
PA14	Piper Aircraft Corp. (USA)	1	Family Cruiser	c								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
PA18	Piper Aircraft Corp. (USA)	1	Super Club	c								
PA23	Piper Aircraft Corp. (USA)	24	Apache	c								
PA24	Piper Aircraft Corp. (USA)	14	Comanche	c								
PA27	Piper Aircraft Corp. (USA)	39	Aztec, Turbo Aztec	c								
PA28	Piper Aircraft Corp. (USA)	93	Cherokee, Archer, Dakota/Warrior	c	✓							
PA30	Piper Aircraft Corp. (USA)	15	Twin Comanche	c								
PA31	Piper Aircraft Corp. (USA)	253	Chieftan, Mohave, Navajo, T-1020	c	✓							
PA32	Piper Aircraft Corp. (USA)	93	Cherokee Six, Lance, Saratoga	c								
PA34	Piper Aircraft Corp. (USA)	100	Seneca	c								
PA38	Piper Aircraft Corp. (USA)	1	Tomahawk	c								
PA39	Piper Aircraft Corp. (USA)	1		c								
PA3T	Piper Aircraft Corp. (USA)	1		c								
PA42	Piper Aircraft Corp. (USA)	4	Cheyenne III/IV, 400LS	c	✓							
PA44	Piper Aircraft Corp. (USA)	33	Seminole	c								
PA46	Piper Aircraft Corp. (USA)	40	Malibu	c								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
PA48	Piper Aircraft Corp. (USA)	1		c								
PA60	Piper Aircraft Corp. (USA)	14	Aero Star 600/700	c								
PARO	Piper Aircraft Corp. (USA)	6	Cherokee Arrow IV	c								
PAY1	Piper Aircraft Corp. (USA)	22	Cheyenne 1	c								
PAY2	Piper Aircraft Corp. (USA)	46	Cheyenne 2	c								
PAY3	Piper Aircraft Corp. (USA)	10	Cheyenne 3	c								
PC12	Pilatus Flugzeugwerke AG (Switzerland)	36	PC-12	c	✓							
PC9	Pilatus Flugzeugwerke AG (Switzerland)	1		c								
RANG	Navion Rangemaster Aircraft Corp. (USA)	1	Rangemaster	c								
S3	Lockheed Corp. (USA)	30	Viking	m	✓							
SBR1	Rockwell International Corp. (USA)	71	Sabreliner 65/40/50/60	c	✓	✓	28	✓	27	✓	2	✓
SBR2	Rockwell International Corp. (USA)	2		c	✓	✓	1					✓
SC7	Short Brothers Ltd. (UK)	8	Shorts SC7 Skyvan, Skyliner	c								
SF24	Saab & Fairchild Industries (Sweden/USA)	1		c								



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
SF34	Saab & Fairchild Industries (Sweden/USA)	1544	Model SF-340	c	✓	✓	1			✓	1	N
SH33	Short Brothers Ltd. (UK)	29	Shorts 330	c								
SH36	Short Brothers Ltd. (UK)	24	Shorts 360	c								
SH60	Short Brothers Ltd. (UK)	7		c								
SH7	Short Brothers Ltd. (UK)	1	Shorts SC7 Skyvan	c								
STAR	Beech Aircraft Company (USA)	4	Starship 2000	c	✓							
SW2	Fairchild Industries (USA)	15	Merlin IIA/B, III/B/C, IVA	c								
SW3	Fairchild Industries (USA)	101	Metro III, Merlin IVC	c								
SW4	Fairchild Industries (USA)	208	Metro IIA	c								
T2	Rockwell International Corp. (USA)	6	Buckeye	m								
T33	Lockheed Corp. (USA)	6	T-33	m	✓	✓	1					
T34	Beech Aircraft Company (USA)	3	Mentor	m								
T34P	Beech Aircraft Company (USA)	1	Mentor T34A/B, E-17	m								
T34T	Beech Aircraft Company (USA)	26	Turbo Mentor T-34C	m	✓							
T37	Cessna Aircraft Company (USA)	44	Cessna 318	m	✓	✓	1	✓	1			N
T38	Northrop Corp. (USA)	156	T-38 Talon	m	✓	✓	25	✓	22			Y



Ac Type	Aircraft Company	##AC	Description	Use	290-410	350-410	##AC	370-410	##AC	410-up	##AC	RVSM cap.
T39	Rockwell International Corp. (USA)	3	Sabreliner 65	m	✓	✓	3	✓	1			Y
T43	Boeing Company (USA)	1	Boeing 737/200 series	m								
T6	Rockwell International Corp. (USA)	2	Texan	m								
T700	Aerospatiale (France)	1	TBM TB-700	c								
TAMP	Aerospatiale (France)	1	Tampico TB-9	c								
TB20	Aerospatiale (France)	1	Trinidad TB-20	c								
TBM7	Aerospatiale (France)	6	TBM TB-700	c								
TOBA	Aerospatiale (France)	1	Tabago TB10C/200	c								
TRIN	Aerospatiale (France)	2	Trinidad TB-20/21	c								
U2	Lockheed Corp. (USA)	2	U-2	m	✓					✓	2	
U21	Beech Aircraft Company (USA)	1	Ute	m								
WW24	Israel Aircraft Industries (Israel)	79	1124 Westwind	c	✓	✓	51	✓	29			Y
Total		32655					7870		3990		237	
Unknown		9098					1560		737		38	
Grand Total		41753			18769		9430		4727		275	



Appendix D Aircraft Data Structure

Aircraft Id	AAL1764			
Aircraft Type	MD80			
Origin	DEN			
Destination	DFW			
Flight Data	Time (GMT min)	Latitude (deg)	Longitude (deg)	Altitude (FL)
	254.1500	39.7670	-104.6500	84
	255.1500	39.6830	-104.6330	117
	255.9170	39.6170	-104.6330	370
	278.8170	36.9830	-103.4500	370
	283.8170	36.5670	-102.7500	370

	320.8170	33.5170	-97.8330	110
	324.8170	33.2000	-97.4330	110
	332.8170	32.7330	-97.0500	110
	335.5170	32.8670	-97.0330	90
Origin Coordinates	Latitude (deg)	Longitude (deg)		
	39.7743	-104.8798		
Destination Coordinates	Latitude (deg)	Longitude (deg)		
	32.8969	-97.0425		
Stage Length (nmi)	559.5521			
Fuel burnt (baseline) (lbs)	4,777			
Fuel savings (with RVSM) (lbs)	450			



Appendix E Distribution of Altitude Changes

The following table provides the number and magnitude of flight altitude changes. The left most column provides baseline altitudes, the top row provides the magnitude of cruise altitude changes (in thousands of feet), and the entries in each cell indicate the number of flights that change that amount (i.e., column heading). For example, 83 flights with a baseline cruise altitude of FL370 had a cruise altitude of FL390 in the RVSM scenario.

FL/Alt Change	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	2	3	0	3	0	8	0	0	0
260	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	8	0	0	0	11	0	0	0	2	1	0	0	1	0
270	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	2	0	0	1	1	1	4	1	2	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0	2	0	3	0	36	1	1	0	0	0	0	3	17	0	0	0	3	0	0	0
290	0	0	0	0	0	0	0	0	1	0	0	1	1	8	0	0	7	13	0	32	5	52	1	3	2	3	0	0	0
300	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
310	0	0	0	0	0	0	1	1	7	2	26	0	0	209	0	4	0	18	299	11	21	0	42	3	0	0	0	0	0
320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
330	0	0	0	0	1	3	1	5	0	39	0	1	0	96	0	376	56	703	2	64	4	69	0	0	0	0	0	0	0
340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
350	0	0	7	1	13	1	33	0	0	298	0	7	0	45	534	60	64	2	226	8	0	0	0	0	0	0	0	0	0
360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0
370	2	0	1	1	0	14	0	0	4	65	0	102	15	212	2	83	14	306	0	0	0	0	0	0	0	0	0	0	0
380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
390	1	0	9	1	0	0	28	3	0	3	19	1	13	2	243	45	0	0	0	0	0	0	0	0	0	0	0	0	0
400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
410	0	0	0	0	1	2	0	0	1	6	0	3	21	62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	3	0	17	3	15	20	63	10	13	415	45	119	52	671	781	581	144	1046	530	127	37	145	44	13	3	14	0	1

